Code Lock

Using a rotary encoder

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Most code locks or electronic entry systems need a 10-way keypad to enter a code number sequence. This design performs the same function but takes a more circular route…

Electronic lock or door entry mechanisms normally use a 10-way numeric keypad to enter the code sequence. Once the correct four-digit sequence is entered a relay is activated and this switches a door-opening device. A novel alternative to the keypad is a rotary encoder coupled with a left/right scrolling single character dot-matrix display to indicate direction of rotation and value of the encoder.

Rotary encoders

Rotary or shaft encoders are not often seen in *Elektor Electronics* projects but this does not mean that they are particularly exotic or difficult to use.

Mechanically they are similar to a standard rotary wafer switch but they have just two wiped contacts. These contacts are staggered so that when the encoder is turned through its detent positions in one direction the closing and opening of contact A will occur before the closing and opening of contact B. Turning the shaft in the opposite direction now causes contact B to close and open before contact A. Each contact changes state once per detent position.

If the shaft were rotated at a constant speed the output waveforms of switch A and B would look like two phase-shifted square waves (**Figure 1**). Rotate the shaft in the other direction and the phase shift between the signals is reversed. They also have no end-stops so it is up to the software to decide what the current switch position is, it can only know if the switch has moved and in which direction.

The encoder specified for this project has a relatively high resolution of 30 impulses per revolution and is also fitted with an additional independent switch with push-to-make contacts. This switch is used to 'enter' the dial setting by pressing the shaft.

The Digiswitch type 427 encoder given in the parts list is stocked by Conrad Electronics (www.int.conradcom.de). The switch company ALPS also manufacture a similar type and these are available from Farnell (order code 733738) (www.farnell.co.uk)

Entering and changing codes.

A PIC Microcontroller is used to read the two-phase signal from the rotary switch and also to output a number to the 5x7-LED matrix display. Turning the knob in either direction causes incrementing or decrementing numbers (0 to 9) to scroll across the display depending on the direction of rotation. The dial is pressed to select the number on the display and the number now scrolls downwards. Once the correct code sequence is entered a relay is activated for a few seconds.

The code sequence can be changed by keeping the dial pressed down when the last number of the current code is entered. The display now flashes to indicate that a new four-digit code can be entered. Once again when the last digit is entered, the dial is held down to signal the end of the new code sequence. The display now shows the code again.

Should you forget the code it can be displayed by shorting out the pins of JP1 and resetting the circuit. The code sequence will now be shown and the display will be switched off after about one minute of no switch activity.

The controller

The circuit diagram in **Figure 2** shows the PIC16F84 as the central component of the circuit. The encoder push button contact is connected to RB0 while the encoder contacts A and B are connected to pins RB1 and RB2. These pins are configured as inputs and the necessary pull-up resistors are integrated on-chip. Port pin RB3 is only used during reset to read the value of jumper JP1.

Pins RB4, RB5 and RB6 are configured as outputs and drive the demultiplexer IC1. This device has open-collector outputs and drives the matrix display rows via transistors T1 to T7. The five columns of the display matrix are driven directly from port pins RA0 to RA4 via current limiting resistors R15 to R19. Port pin RB7 switches the relay via transistor T8. Diode D1 is necessary to prevent back-emf from destroying T8 when the relay is switched off. The relay specified does not have mains rated contacts and is only suitable for switching 125 VAC with a maximum load of 1 A.

The circuit draws 12 mA quiescent current rising to around 50 mA when the display is active and 180 mA with the relay pulled in. A 78L05 (IC3) voltage regulator is included on board to produce 5 V for the circuit. To avoid excessive dissipation the input supply voltage should not be any greater than 12 V.

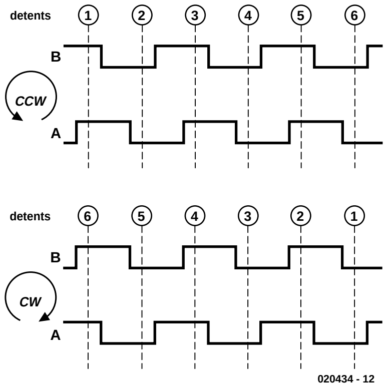

Figure 1. Output waveform of the rotary encoder.

Component placement

The circuit components all fit on a single-sided PCB. The majority of the resistors are mounted upright to save space. Ensure that the 12 V power supply leads are correctly connected to the '+' and '0' pads on the PCB. IC2 should be fitted to the PCB via a socket to ensure that it can easily be removed for reprogramming if a software update is

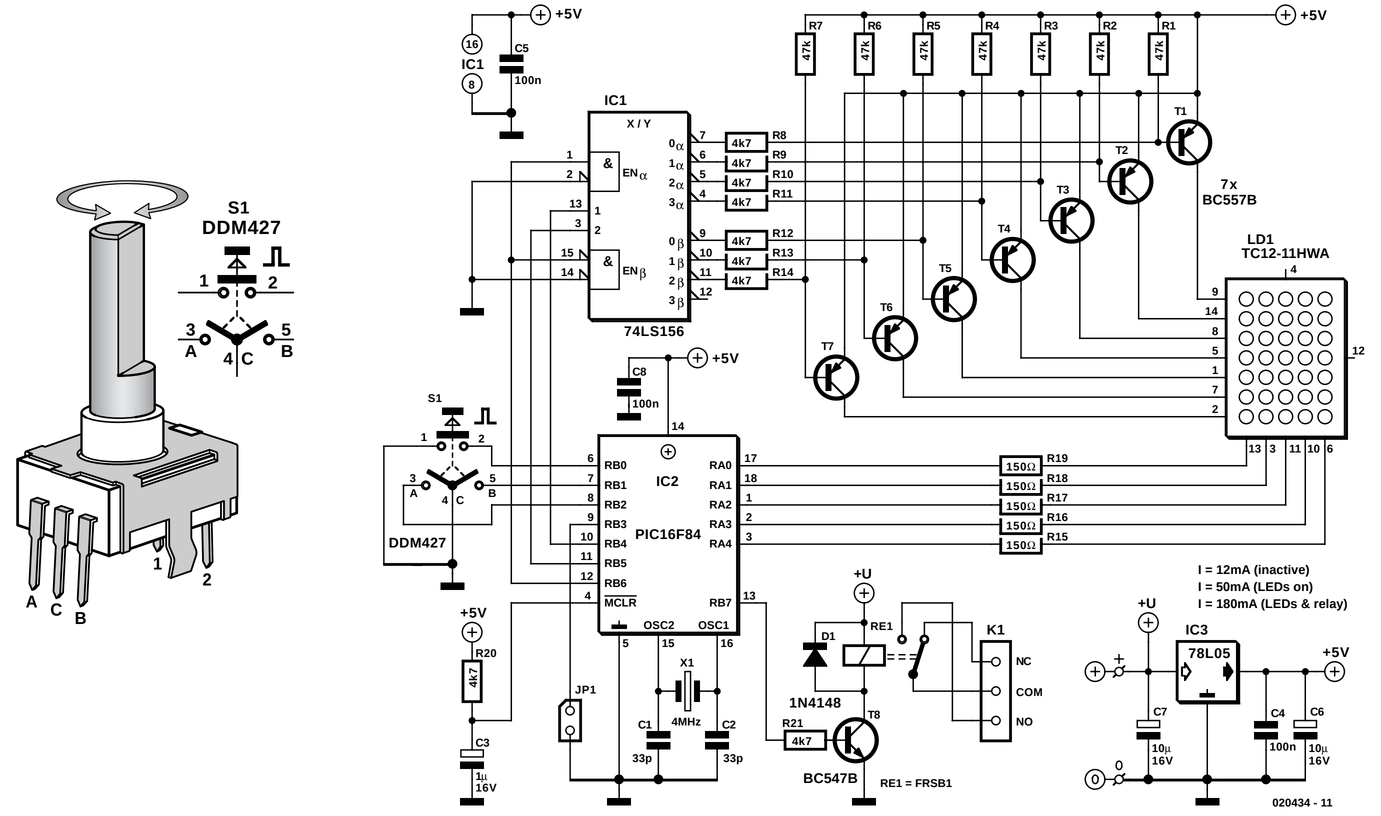

Figure 2. The code lock circuit diagram.

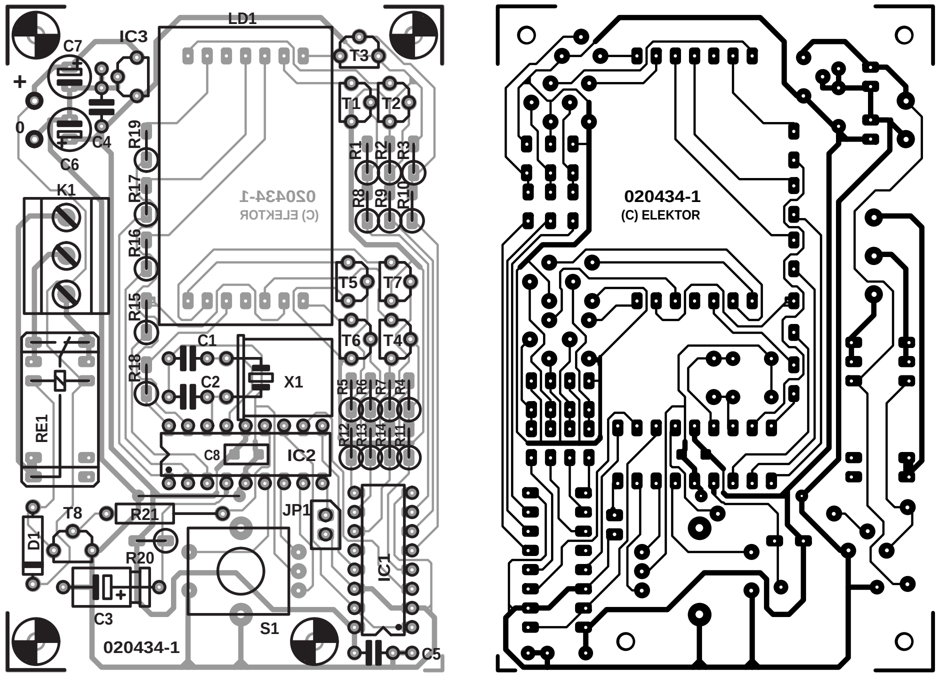

Figure 3. The single-sided PCB is quite tightly packed and does not use any SMD components.

COMPONENTS LIST

Resistors:
R1-R7 = 47kΩ
R8-R14,R20,R21 = 4kΩ7
R15-R19 = 150Ω

Capacitors:
C1,C2 = 33pF
C3 = 1µF 16V
C4,C5 = 100nF
C6,C7 = 10µF 16V radial

Semiconductors:
IC1 = 74LS156 or 74HC(T)156
IC2 = PIC16F84 or PIC16C84A-4/P, programmed, order code **020434-41**
IC3 = 78L05
D1 = 1N4148
T1-T7 = BC557B
T8 = BC547B

Miscellaneous:
X1 = 4MHz quartz crystal
LD1 = 5x7 matrix display (Conrad Electronics # 160490)
S1 = Rotary encoder type 427 (small model) (Conrad Electronics # 705594)
RE1 = FRS1B-S, 12V, 1 x changeover (Conrad Electronics # 505196)
JP1 = 2-way PCB terminal block with jumper
K1 = 3-way PCB terminal block, lead pitch 5mm
2 solder pins
PCB, order code **020434-1**
Disk, source and hex code, order code **020434-11** or **Free Download**

required in the future.

Once all the components have been fitted and the board has been given a thorough inspection the 12 V input supply can be connected. The circuit should take around 50 mA and the number '0' should be displayed if everything is in order. If the circuit does not seem to be working it will be necessary to investigate a little further. Disconnect the power source and remove IC2 from its socket. Reconnect power and test the display multiplex circuitry by using a wire link to connect pins RA0 through RA4 one after another to ground (pin 5 on IC2 socket) while linking pins RB4, RB5 and RB6 to ground in a binary sequence, this will illuminate and test each individual LED in the display. The voltage level at the reset input $\overline{\text{MCLR}}$ should be 5 V and finally the crystal oscillator can be checked with an oscilloscope.

Software

All the software was written in assembler using MPASM. The complete software development environment can be downloaded freely from the Microchip website. The software for this project consists of two source files:

`Display.asm` contains the display character generator for the numbers 0 to 9.

`Codelock.asm` The main codelock program.

These can be either freely downloaded from the *Elektor Electronics* website or supplied on a diskette (see Readers Services). At reset the microcontroller checks if it is the first time that the circuit has been used by reading the first memory location in EEPROM. The microcontrollers EEPROM is always supplied from the factory with 0xFF written to each memory location. Whenever the unlock code sequence is changed the value 0x3D is written to this first byte. If this value is not present the microcontroller knows that it is the first time the circuit has been used and will write the default code sequence 1234 into its EEPROM.

When initialisation is complete the program enters its main loop where it takes care of display multiplexing and reading the input port. The contents of the bit-variable MODE indicate display scroll direction, input switch debounce period, relay switching time and new code is entry.

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Free Downloads

PIC software. File number: **020434-11**.zip, contains:

- CODELOCK.HEX
  Hex code for the PIC
- CODELOCK.ASM
  Source code (Assembler)
- DISPLAY.ASM
  Source code (Character set)

PCB layout in PDF format.
File number: **020434-1.zip**
www.elektor-electronics.co.uk/dl/dl.htm,
select month of publication.